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Device for Abrasive Machining of Surfaces of Components, particularly Optical Components and Work Pieces

Technical Field

The invention relates to a device for abrasive machining of surfaces of components, particularly optical components or work pieces.

Prior Art

Various methods and devices are known for abrasively machining surfaces, as is necessary for example for the manufacture of optical components such as lenses, prisms, plane parallel plates etc, but also of molds for casting or molding optical components,. With many of the known methods or devices a surface to be machined is first subjected to a grinding operation, and possibly also to a fine grinding operation using contacting tools such as, for example, disk-wheel grinders, spherical grinders etc., and subsequently to a polishing operation using a polishing tool. Instead of applying grinding operations it is also known to subject the surfaces to turning using a suitable lathe chisel on a lathe, or to apply another machining-down method. Most machining operations in which relatively much material is removed require a final polishing of the surface, at least when optical surfaces are to be produced. The polishing of spherical surfaces is performed in prior art on a large surface using a polishing disk.

Problems always arise with conventional methods and devices when aspherical surfaces are to be produced. The manufacture of aspherical surfaces is accomplished according to prior art with tools such as spherical grinders which engage the surface to be machined in a more or less point-wise manner and are guided along a track across the surface to be machined. In this, according to the design

of the tool, the surface is either ground or polished. However, for reasons of time and cost, aspherical surfaces are frequently only ground along a track; the polishing is then effected not along a track but on a large surface. Particularly when the asphericity is comparatively large, as is the case for example with progressive spectacle lenses, the surface polishing leads to a more or less large polishing error which must be compensated by means of suitable fabrication corrections during preceding processing operations.

Furthermore, it is known to treat surfaces of work pieces and particularly optical components with jets of fluid. However, the devices proposed for this require a relatively large outlay, yet do not permit of any fast manufacture of the surfaces because of the more or less point-shaped working of the surfaces.

Description of the Invention

The invention is based on the object of providing a device for abrasive machining of surfaces, and particularly for grinding and/or polishing of surfaces of optical components, which permits fast machining of the surface irrespective of the shape of the particular surface being machined.

An achievement of the object in accordance with the invention is set out in patent claim 1. Further developments of the invention are the subject matter of claims 2 to 10. Possible uses of the device of the invention are claimed in claims 11 to 14.

In accordance with the invention, the device for abrasive machining of surfaces and particularly for grinding and/or polishing optical components comprises a tool having a fluid inlet and a fluid outlet. A supply unit conveys a liquid in which abrasive agents are dissolved to the fluid inlet. This liquid flows through the tool to an outlet from which it emerges from the tool. According to the invention, this tool is positioned by a positioning means in such manner relative to the surface to be machined that the outlet from which the liquid emerges faces the surface to be

machined, in particular with a small intervening space. Here it is important that the area of the annular gap defined between the boundary walls of the outlet and the surface to be machined be smaller than the cross-sectional area of the inlet. Because of this, the liquid in which abrasive agents are dissolved emerges from the annular gap along the radial direction of the tool under a pressure which is substantially higher than the pressure under which it flows into the inlet. The machining of the surface of the work piece is performed by the liquid flowing out in the radial direction. The surface in the region of the annular gap is thus machined so as to be linearly ground or polished in accordance with the kind of abrasive agents dissolved in the liquid. Because of the linear working, the machining time is shortened by some orders of magnitude when compared with that of known methods or devices in which there is a substantially point-shaped engagement between the tool and the work piece.

In this, the ratio of the pressure under which the liquid flows into the tool to the pressure under which the liquid emerges from the annular gap is inversely proportional to the ratio of the cross-sectional area of the inlet to the cross-sectional area of the formed annular gap. This means that the "processing pressure" can be set by the positioning of the tool relative to the work piece – in other words, by an adjustment of the height of the annular gap – without the pressure under which the supply unit conveys the liquid having to be changed.

With this it is a special advantage of the invention that comparatively low pressures may be used on the inlet side: in particular, the supply unit can convey the liquid at a pressure of less than 20 bar, preferably less than 5 bar, and possibly even at only atmospheric pressure. In order that a pressure increase which is of advantage for the processing operation and the processing speed may be achieved, it is preferred for the cross-sectional area of the inlet to be greater than the cross-sectional area of the formed annular gap by a factor of at least 5. With this it is furthermore preferred for the height of the formed annular gap to be smaller than 3 mm and, in particular, about 1 mm.

In any case, it is of advantage for the positioning means to have a control unit for controlling the positioning of the tool according to the surface data of the surface to be produced. In this, it is preferred for the positioning of the tool to be so effected that the height of the annular gap remains constant during a shift along respective tracks.

In principle, the positioning device can shift the tool relative to the work piece, i.e. to the surface to be machined, along any tracks. For example, the track may be a meandering track, with either the tool or the work piece or both being moved.

Furthermore, the tool and the component of which a surface is to be machined can be simultaneously shifted. In the case of rotationally symmetrical surfaces, or surfaces deviating only slightly from rotational symmetry, it is preferred for the tool to be moved along tracks which extend through the surface apex, and simultaneously for the work piece or the component being machined to be rotated by a rotary unit around an axis which, in particular, is the rotational axis of the surface to be produced.

In order to effect a homogeneous machining of the surface along the annular gap it is furthermore preferred for the outlet to have a circular cross-section, and for the tool to have an outside contour in the shape of a (regular) cylinder at least in the region of the outlet.

In a further preferred development of the invention, a machining of the surface occurring only linearly (or circularly) in the region of the annular gap, and not also at the center of the outlet, is achieved by the cross-sectional area of the inlet being smaller than that of the outlet.

Furthermore, it is preferred for the size of the tool to be conformed to the shape of the surface to be machined:

For a machining of plane surfaces the outer diameter of the tool in the region of the outlet may be of the order of magnitude of one half of the aperture of an optical component, so that a very fast machining of the surface is achieved with the greatest possible homogeneity of the machining operation. For a machining of curved surfaces, the outer diameter of the tool is preferably of the order of magnitude of the smallest radius (smallest principal radius of curvature) of the surface; hereby it is ensured that the height of the annular gap is practically constant along the entire formed annular gap.

The device of the invention can be used for machining any surfaces of components or work pieces which in principle may be of any material. For example, because of the high working speed, the device of the invention can be used for machining steel turbine blades.

Particularly preferred, however, is the use of a device of the invention for grinding and/or polishing optical surfaces. In the case of lenses, prisms, plane parallel plates etc. – i.e. directly manufactured optical components – the work pieces concerned may be of quartz, optical glass or synthetic material; if molds are to be produced for the casting and/or molding etc. of optical components, the work pieces may also be of a metal such as steel or a ceramic material.

Because the kind of abrasion depends substantially not on the design of the tool, but on the kind of liquid or abrasive agent(s) dissolved in the liquid used, one and the same device may be used successively for grinding, possibly fine grinding, and finally for polishing a component or work piece in one and the same mount. A change between the individual kinds of machining then necessitates merely a replacement or exchange of the working fluids used in each case.

In every case, however, it is especially preferred for the device of the invention to used for machining aspherical surfaces.

Brief Description of the Drawings

In the following the invention will be described by way of example without limitation of the general inventive concept, with the aid of embodiments with reference to the drawings to which attention is expressly drawn concerning the disclosure of all details of the invention not described more explicitly in the text. Shown by:

Fig. 1 is a device according to the invention, used in machining a plane surface; and

Fig. 2 is a device according to the invention, used in machining a curved surface, and particularly an aspherical surface.

Description of an Example of Embodiment

Fig. 1 illustrates a device according to the invention, of which only a tool 1 is shown, used in machining a plane surface 21 of a work piece 2 which, without limitation of the generality, is a plane parallel plate. The tool 1 has an inlet 11, and an outlet 12 having a cross-sectional area which is greater than that of the inlet 11. A not shown supply unit conveys a liquid in which abrasive agents such as grinding agents or polishing agents are dissolved into the inlet 11 of the tool 1. The tool 1 is positioned by a not shown positioning unit in such manner relative to the work piece 2 that between the boundary walls 13 of the outlet 12 and the surface 21 an annular gap 3 is formed, the cross-sectional area of which is smaller and preferably substantially smaller than the cross-sectional area of the inlet 11. Hereby the pressure with which the liquid emerges from the annular gap 3 is increased in the ratio of the cross-sectional areas of the inlet 11 and the annular gap 3. The pressure which is effective for the machining of the work piece surface 21 is thus substantially greater than the delivery pressure.

The not shown positioning means shifts the tool 1 parallel to the surface of the work piece 2, whilst an also not shown rotary unit rotates the work piece 2 about an axis 22, so that the line-shaped engagement along the annular gap 3 is shifted across the work piece 2 in such manner that the entire surface 21 is uniformly machined, for example polished.

The diameter of the tool 1 is of the order of magnitude of the radius of the work piece 2.

Fig. 2 shows a device in accordance with the invention during a machining of a curved, in particular aspherical surface 21' of a work piece 2. The same parts are provided with the same reference signs, so that their renewed introduction can be dispensed with. The diameter of the tool 1 is of the order of magnitude of the smallest radius of the aspherical surface 21'. The positioning unit, also not shown, shifts the tool 1 along tracks passing through the apex of the surface 21'. At the same time the work piece 2 is rotated around an axis 22 of rotation passing through the apex.

In the foregoing the invention has been described with the aid of examples of embodiment without limitation of the general inventive concept.